Table 13.2.6

Thickness of plate, in*	0.5	0.6	0.8	1	1.2
Horsepower for plate 120 in wide†	10.0	12.0	18.0	27.0	40.0
Horsepower for plate 240 in wide†	30.0	30.0	40.0	55.0	75.0

*1 in = 2.54 cm.
†1 hp = 0.746 kW.

upright. Heavy ship plates are rigidly clamped down and bent by a roll operated by two hydraulic pistons. For angular bends or for the production of warped surfaces, the pistons can be operated independently or together. In vertical machines, angles and other rolled shapes are bent between suitably shaped rolls. Pipes are filled with sand to prevent flattening when being bent. For some work, pipes are bent hot between suitable forms operated by hydraulic pressure.

The **rotary swaging machine** for tapering, closing in, and reducing tubes, rods, and hollow articles is essentially a cage carrying a number of rollers and revolving at high speed; e.g., 14 rolls in a cage revolving at 600 r/min will strike 8,400 blows per min on the work.

A rapid succession of light blows is applied to a considerable variety of commercial **riveting** operations such as pneumatic riveting. Another method of riveting, described as spinning, involves rotating small rollers rapidly over the top of the rivet and at the same time applying pressure. Neither of these methods involves pressures as intense as those used in riveting by direct pressure, either hot or cold. Power presses and C-frame riveters, employing hydraulic pressure or air pressure of 80 to 100 lb/in^2 (550 to 690 kN/m^2), are figured to apply 150,000 lb/in^2 (1,035 MN/m^2) of the cross section of the body of the rivet for hot-working and 300,000 lb/in^2 (2,070 MN/m^2) for cold-working. The plates should be pressed together by a pressure of 0.3 to 0.4 times that used in riveting.

13.3 WELDING

by Edwin G. Shifrin

REFERENCES: From the American Welding Society (AWS): "Welding Handbook" (six volumes); "Structural Welding Code"; Filler Metal Specifications; "Welding Terms and Definitions"; "Brazing Manual"; "Thermal Spraying"; "Welding of Chromium-Molybdenum Steels." From the Lincoln Arc Welding Foundation: Blodgett, "Design of Weldments"; Blodgett, "Design of Welded Structures." "Procedure Handbook of Welding," The Lincoln Electric Co. "Safety in Welding and Cutting," ANSI.

FUNDAMENTALS OF WELDING

A weld is defined by the AWS as a localized coalescence of metal wherein coalescence is produced by heating to suitable temperatures, with or without the application of pressure, and with or without the use of filler metal. Filler metal can be used only if the base metal and filler metal are compatible (in terms of crystal structure) and if there is atom-to-atom contact (which is possible only if the surfaces are clean and free of foreign material). If the base metals are not compatible, it is necessary to use either a process that does not melt them (such as brazing) or a filler metal that is different from the base metals but fuses to them. Whenever the base metal melts, there is a mixture of base and filler metals. There is also likely to be a heat effect on the structure or properties of the base metal next to the weld. The base metal affected in this way is called the *heat-affected zone (HAZ)*. Base metal sometimes contains impurities that enter into the weld or are affected adversely by the welding process and its attendant stress. The filler metal may have a melting point approximately the same as the base metals (as in arc or gas welding), or it may have a lower melting point but above 840°F (450°C) (as in brazing). This definition distinguishes welding from mechanical joining and adhesive bonding. The 840°F limit distinguishes brazing from soldering, which is excluded herein. The definition includes processes falling under six general categories: arc welding, gas welding, resistance welding, brazing, solid-state welding, and "other" processes.

Basic **types of groove welds** are shown in cross section in Fig. 13.3.1, top; at bottom are views of joints commonly used in plate and sheet fabrication. Figure 13.3.2 gives typical **dimensions** for plate-edge preparation for making butt joints with six types of groove welds deposited by the manual shielded metal-arc process.

The basis for weld-groove design is to provide a shape and size of opening that will enable a sound deposition of filler metal and permit full penetration if desired, under given conditions, with maximum economy. For other welding processes that employ filler metals, groove dimensions may vary from those shown in Fig. 13.3.2. For instance, in submerged arc welding, greater power input is available and deeper penetration is possible. Therefore, smaller weld grooves are possible.

To establish uniform and simple drafting practice, welding symbols have been standardized by AWS and adopted by ANSI. Figure 13.3.3 shows several basic symbols.

DESIGN STRENGTHS

The AWS Structural Welding Code (D1.1) permits, in general, the same values of stress for butt welds as are applicable to the base metal, except that for fatigue loading, special for-